

**Acronym:** InSPACE-2

**Payload Title:** Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions – 2

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**Sponsoring Agency:** National Aeronautics and Space Administration (NASA)

**Increment(s) Assigned:** 15, 16, 17, 18, 19, 20

**Brief Research Summary (PAO):** Particle dynamics of magnetorheological fluids (fluids that change properties in response to magnetic fields) are studied to help understand adaptable new fluids for use in such applications as brake systems and robotics.

**Research Summary:**

- InSPACE-2 will study the fundamental behavior of magnetic colloidal fluids under the influence of various magnetic fields. Observations of the microscopic structures will yield a better understanding of the interplay of magnetic, surface and repulsion forces between structures in magnetorheological (MR) fluids
- These fluids are classified as smart materials which transition to a solid-like state by the formation and cross-linking of microstructures in the presence of a magnetic field. On Earth, these materials are used for vibration damping systems that can be turned on or off.
- This technology has promise to improve the ability to design structures, such as bridges and buildings, to better withstand earthquake forces.

**Detailed Research Description:** The Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsion - 2 (InSPACE-2) investigation is a continuation of the InSPACE investigation, begun on ISS Expedition 6, providing new and improved samples for operation in the Microgravity Science Glovebox (MSG). Magnetorheological fluids (MR) are suspensions of paramagnetic particles that can quickly solidify when exposed to a magnetic field and return to their original liquid state when the

magnetic field is removed. This solidification process produces useful viscoelastic properties that can be harnessed for a variety of mechanical devices from intricate robotic motions to strong braking and clutch mechanisms. Understanding how to precisely control these properties and states will enable the use of MR fluids as a working fluid in exploration robots to produce a range of articulated motions ranging from delicate (as if picking up an egg) to firm response, and proper encapsulation pressure around bone fractures. Current robotic technology depends on conventional mechanical components (gears, dashpots, and clutches) while MR fluid interfaces provide significantly faster response, strength, tenability, and physical flexibility, to enhance human and robotic movement and strength.

Gravitational effects in MR fluids are manifested as variations in particle concentration and phase separation due to particle sedimentation, directly impacting rheological (viscoelastic) properties and application performance. Long-duration microgravity time is needed to study the internal structural evolution in the MR fluids in the absence of these additional effects. InSPACE-2 will provide feasibility data on the gelation transition in MR fluids under steady magnetic fields and perform runs using new samples with an improved cell design for imaging the resulting large aggregate structures, based on the previous InSPACE data.

InSPACE-2 hardware consists of two new Helmholtz coil assemblies containing sealed vials of MR fluid and eight new vial assemblies that hold the test fluid. The new hardware will interface with the InSPACE hardware currently on ISS. InSPACE-2 data will significantly impact design of human robotic interfaces for exploration missions.

**Project Type:** Payload

**Images:**



Video Screen Shot of Expedition 13 Science Officer Jeff Williams performing the final session of InSPACE operations during his stay on ISS.



NASA Image: ISS016E021067 - Expedition 16 Commander Peggy Whitson works with the InSPACE-2 (Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions-2) experiment in the Microgravity Science Glovebox (MSG) in the U.S. Laboratory/Destiny.

**Operations Location:** ISS Inflight

**Brief Research Operations:**

- InSPACE-2 is performed in the Microgravity Sciences Glovebox (MSG).
- After a crew member sets up the experiment hardware and inserts the sample cartridge, the experiment is operated from Earth via ground commanding.

- Crew members must periodically change samples as well as data tapes.
- Video of MR fluids in varying magnetic fields, pulse frequency and particle size is recorded on data tapes for return to the principle investigator for analysis.

**Operational Requirements:** InSPACE-2 will be conducted inside the MSG work volume, and the hardware will be powered (120 vdc) via MSG. The experiment runs will be recorded by MSG's video system. Using the optics from InSPACE-1 already on ISS, InSPACE-2 will visually study new samples. An improved cell design over that used in InSPACE-1 will be used for better imaging of the resulting aggregate structures. The new cells are dimensionally very thin in one direction which reduces the optical thickness in that direction and thus provides better viewing. A new coil is also provided that allows the substitution of multiple samples in two orthogonal orientations for alternate views. InSPACE-2 will provide data on the performance of magnetorheological (MR) fluids in a microgravity environment, under steady and intermittent operation (pulsed fields). InSPACE-2 is not a fully automated payload. The crew will be responsible for in-orbit operations, such as sample changes and video tape changes.

**Operational Protocols:** The crew will set up InSPACE inside the MSG work volume and conduct the 27 experiment runs using the glove ports. They will change out the coils after nine experiments and replace video tapes as necessary.

**Review Cycle Status:** PI Reviewed

**Category:** Physical and Biological Sciences in Microgravity

**Sub-Category:** Physical Sciences

**Space Applications:** At the practical level, these fluids are used in electromechanical interfaces and devices in which the fluid is operationally exposed to similar fields which can affect their operation. Current commercial MR fluid products include tunable dampers and brakes, while future applications in robotics, clutches, and a host of vibration-control systems are envisioned.

**Earth Applications:** The study of MR fluids on Earth is difficult because the small magnetic particles remain suspended while the sediments (large particles) sink. The low-gravity environment that is provided on the ISS will eliminate the effects of sinking sedimentation. After the magnetic field is applied to a MR fluid, the microstructures form a rigid lattice that causes the suspension to stiffen. The rapid transformation of these fluids without the iron oxide grains clumping have many possible technological applications on Earth, especially for actuator-type devices. This technology has promise to improve the ability to design structures, such as bridges and buildings, to better avoid earthquake damage.

**Manifest Status:** Inactive

**RPO:** Life Support and Habitation - GRC (LSH-GRC)

**Previous Missions:** InSPACE, the precursor to InSPACE-2 was performed on ISS Expeditions 6, 7, 12 and 13.

**Related Publications:**

Gast AP, Furst EM. Chain Dynamics in Magnetorheological Suspensions. Fourth Microgravity Fluid Physics and Transport Phenomena Conference, Cleveland, OH. Aug 12 - 14, 1998.

**Web Sites:**

[NASA Fact Sheet](#)

[InSPACE Research Objective](#)

**Related Payload(s):** InSPACE, PFMI

**Last Update:** 10/2/2006